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Forecasting Research Division
Technical Report No. 144

Developments in the use of a roaming search area when generating satellite winds using water vapour imagery

by

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21 st December 1994

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1 Introduction

The capability now exists to produce satellite winds for six areas of the globe from fulldisk METEOSAT water vapour imagery, using standard correlation techniques, as described in the paper 'Water Vapour Winds from METEOSAT: Theory and Practice', by Lunnon et al., 1994 (published in the Proceedings of the 10th METEOSAT Scientific Users' Conference). (These six areas are plotted in figure 1, along with the positions of radiosonde stations.) However, there are problems using the search algorithm developed for the NW Europe (AUTOSAT-II) region for some of these areas. This is because the search area is sized according to model forecast data; since the model is liable to be less accurate in other parts of the disk than Europe, relatively few winds are produced in these areas (see figure 2).

This problem can be alleviated by using a 'roaming' search area, i.e. one that can move; this produces many more winds (figure 3). However, a subjective analysis of these extra winds indicates that several are spurious (compare the winds for stations 17240 and 17607 in figure 3). Therefore, a method was required to make the roaming search area more 'intelligent', i.e. to be able to decide whether it was worthwhile using the roaming search area for a particular wind or not. Examination of the *initial* correlation surfaces of both valid and spurious winds produced using the roaming search area indicated that characteristics of these correlation surfaces could be used in order to determine whether the roaming search area should be employed.

2 Method

Winds are produced for the six areas shown in figure 1 over the sites of radiosonde ascents in those areas (note that within the Atlantic area, winds are produced on a regular grid). The choice of these areas reflects the occurence of radiosonde data up to 100hPa; thus South America and central Africa are excluded because there are very few ascents to 100hPa in those areas. The size of the search area over which the correlation is performed is determined by considering a cuboid of model winds over the sonde site, the top and bottom levels of the cuboid being chosen such that the derived satellite wind will be representative of a height between these two levels. The minimum and maximum of the u- and v-components for these winds are found; these then determine the limits of the search area (allowing for a degree of error).

The basic method behind the roaming search area is illustrated in figure 4. The initial correlation surface is marked with the bold outline; as can be seen, the peak value for this surface is on its edge. Therefore the search area is moved (dashed outline) so that this point is at its centre, and the correlation surface recalculated. This process continues until either a peak is found in the body of the surface, or three iterations are performed.

Examination of the initial correlation surfaces of valid winds and spurious winds indicated that the peaks were much sharper for the surfaces of valid winds. This 'sharpness' was quantified using two measurements:

1. the ratio of the peak correlation value to the average correlation value of all points in the surface

2. the difference between the highest contour value of the correlation surface and the lowest

The winds generated for five different dates were examined, and these two values were calculated for all winds generated using the roaming search area, together with the amount in pixels by which the peak moved from the first correlation surface compared with the final one. The values for the winds in figure 3 are given in table 1.

WMO station number	Peak ratio	Contour spread	Peak displacment
15730	1.126	0.222	0.35
16320	1.267	0.339	0.43
16622	1.088	0.161	0.07
17130	1.036	0.086	2.50
17240	1.216	0.400	0.33
17352	1.566	0.408	6.30
17607	1.067	0.124	3.94
37018	1.007	0.015	0.53
37054	1.009	0.020	0.60
37789	1.099	0.206	0.13
40001	1.484	0.716	0.17
40007	1.480	0.516	1.36
40080	1.061	0.144	5.60
62053	1.154	0.249	5.93
62300	1.328	0.447	0.49
62305	1.262	0.382	0.49

Table 1. Correlation surface values for winds produced using roaming search area

The winds generated using the roaming search area were visually inspected in order to determine which were spurious (by comparing with nearby valid winds, etc.). The values of the peak ratio and the contour spread for these winds were then analysed, and the following thresholds were set: if the peak ratio was below 1.15, *and* the contour spread was below 0.2 for the initial correlation surface, the roaming search area would not be used, as a spurious wind would probably be generated. Examples of the correlation surfaces are shown in figures 5(a) and 6(a); for figure 5(a), which corresponds to a valid wind, it can be seen that there is a steep contour gradient on the initial correlation surface, together with a relatively high peak ratio. For the spurious wind (figure 6(a)), the contour gradient is much shallower, together with a lower peak ratio.

It was also noticed that in the vast majority of cases where a spurious wind was produced, the displacement of the peak in the final correlation surface compared with its position in the initial correlation surface was greater than 2 pixels. Thus, a further constraint was added; if a wind produced using the roaming search area had a peak displacement greater than 2 pixels, the wind was flagged as spurious. The final correlation surfaces for the two example winds above are given in figures 5(b) and 6(b); it can be seen that the peak displacement is much less for the valid wind than for the spurious one.

The above criteria were added to the search algorithm, and the satellite images reprocessed in order to produce new wind fields.

3 Results and Conclusions

An example of the winds produced using the modified search algorithm is given in figure 7. The results are encouraging, as more winds can be produced without significantly increasing the processing time required. Table 2 shows how the percentage yield of winds in all areas is improved using this algorithm. It is clear, however, that further modifications are required. Since the distinctions made between valid winds and spurious winds were subjective, the thresholds set above will probably need to be modified once regular validation of the winds against radiosonde ascents begins (this requires wind weighting functions for each wind). In addition, since the accuracy of the model forecast varies between regions, it may be necessary to take account of this by having separate thresholds for each different region in the algorithm. It is hoped that the collection of ESOC winds together with the associated model data will provide more information in this area.

Region	% Yield without roaming search area	% Yield with roaming search area
Europe	43.4	52.2
Atlantic	46.5	55.7
Mediterranean	21.2	32.9
Middle East	19.7	26.2
North Africa	35.9	43.4
South Africa	13.6	25.2

Table 2. Percentage wind yields without and with roaming search area

The criterion for the peak displacement (if it is greater than two pixels the wind is flagged as spurious), is thought to be reasonable since if the wind produced differs too much from the model prediction, it will probably be ignored anyway by the model assimilation scheme.

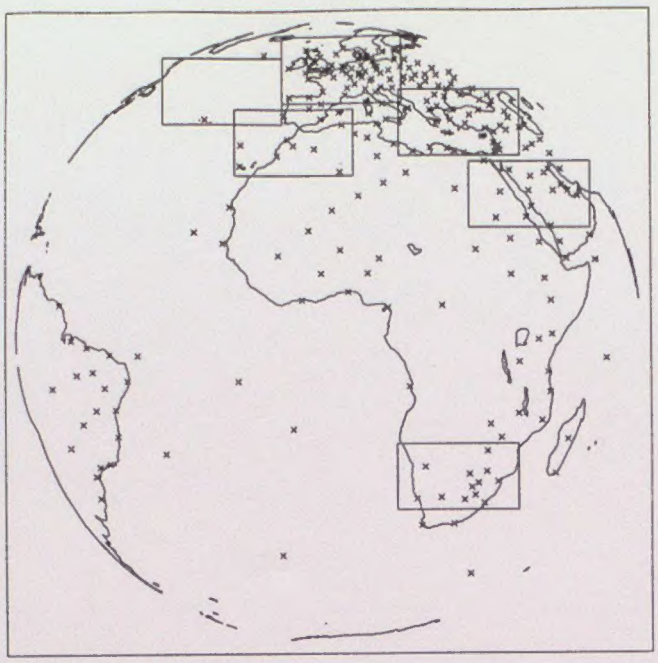


Figure 1. Regions of fulldisk currently processed for WV winds

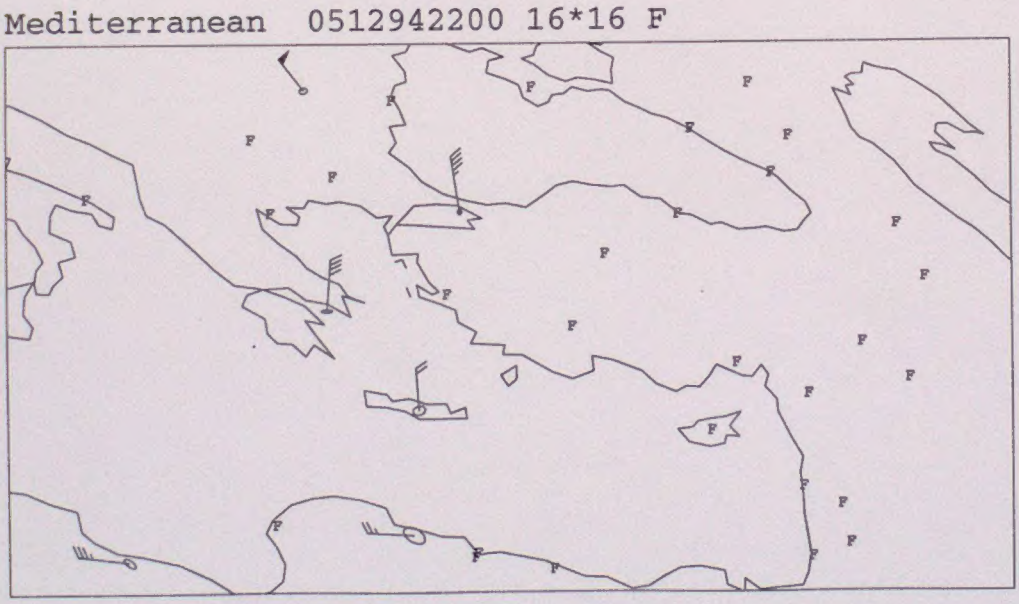


Figure 2. Winds for 5/12/94 22Z, produced using 16×16 pixel template without roaming search area (F indicates failure to find wind)

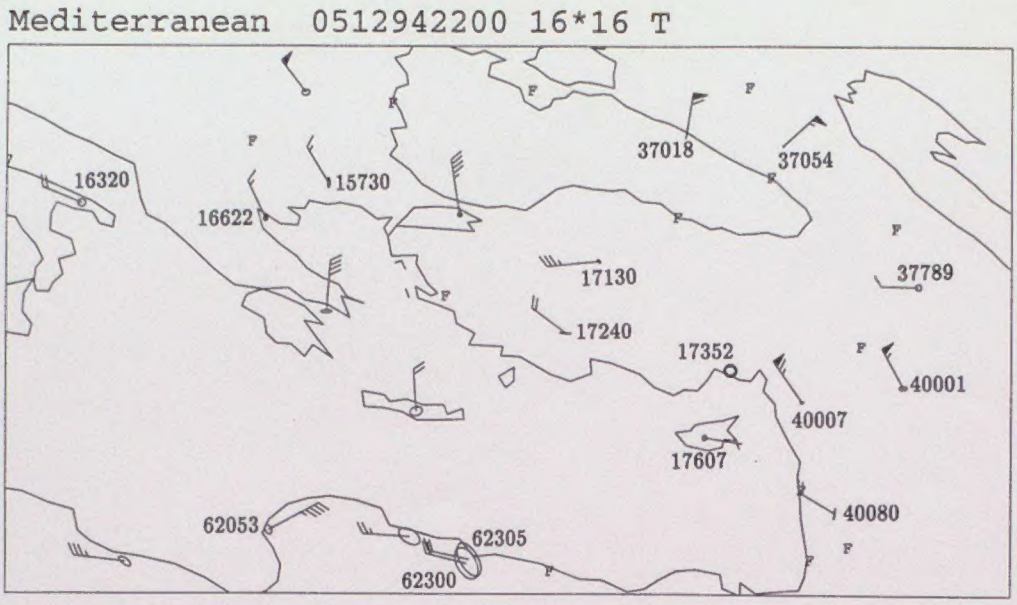


Figure 3. Winds for 5/12/94 22Z, produced with roaming search area

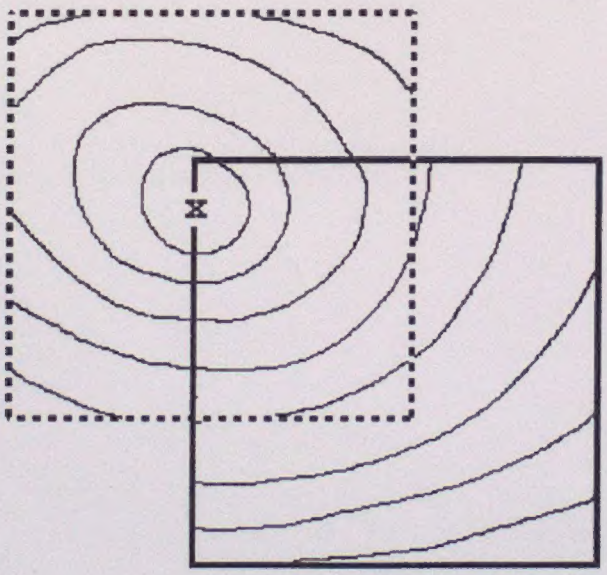
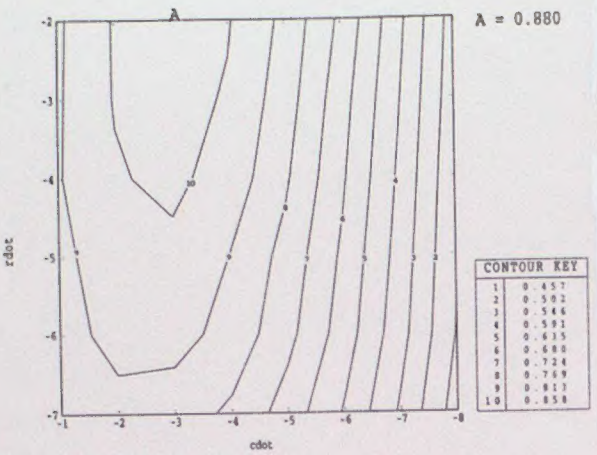
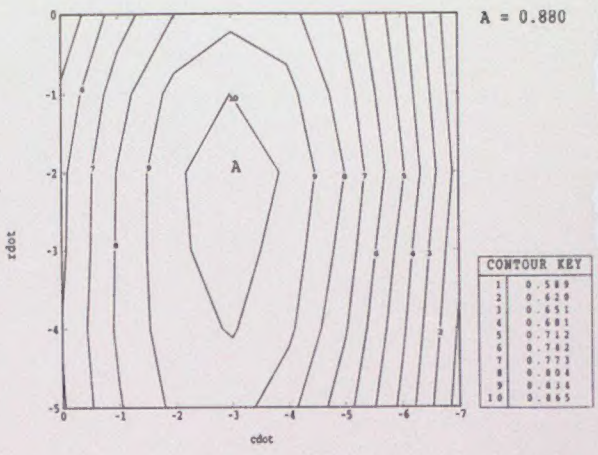


Figure 4. Basic principle of roaming search area

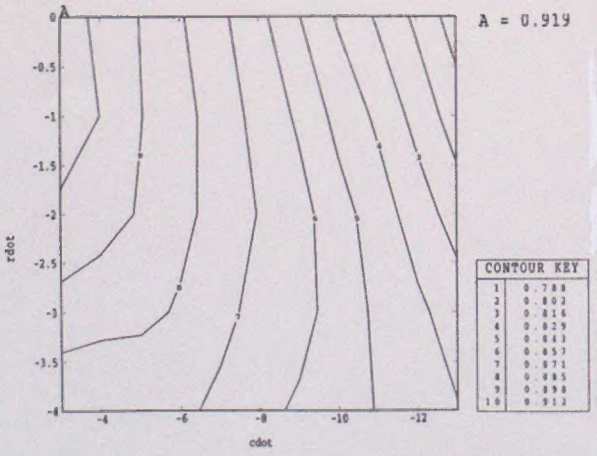


(a) initial

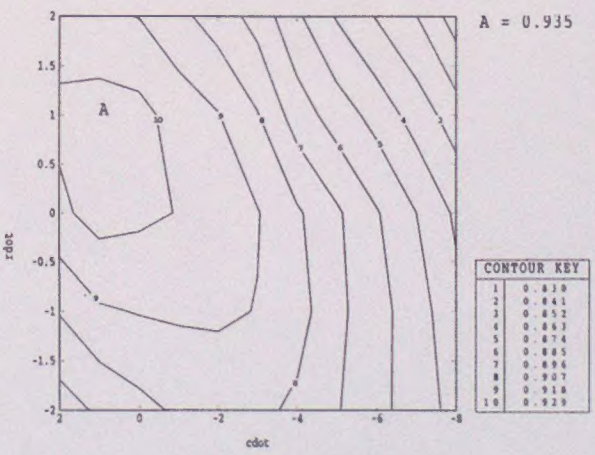


(b) final

Figure 5. Correlation surfaces for valid wind at 17240



(a) initial



(b) final

Figure 6. Correlation surfaces for spurious wind at 17607

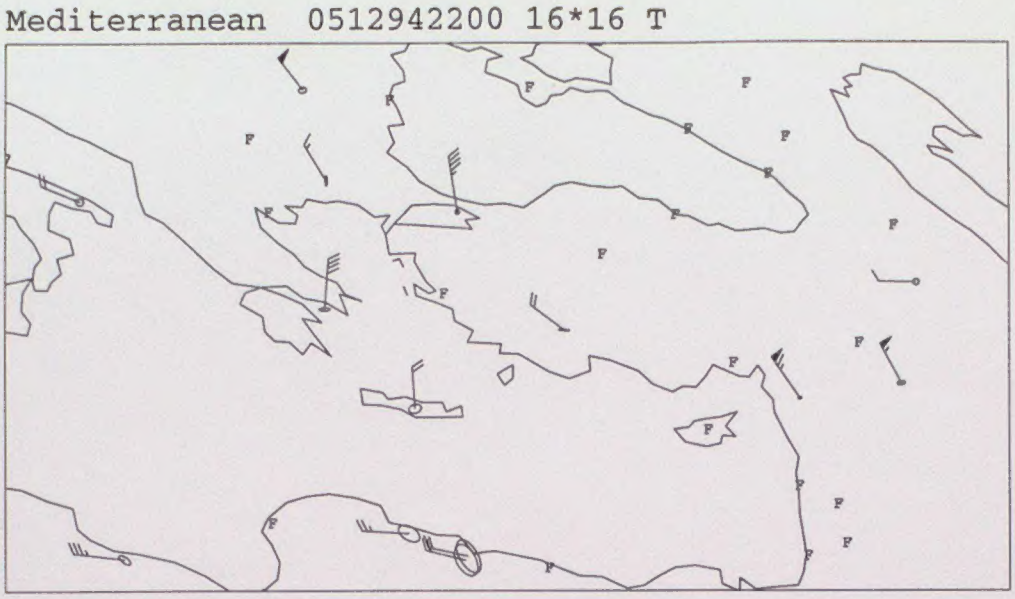


Figure 7. Winds for 5/12/94 22Z, produced with selective use of roaming search area